

IMPROVING PREDICTIONS OF CROWN
DYNAMICS IN THE FOREST VEGETATION
SIMULATOR

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**Phase 1 Final Report
Joint Venture Agreement 03-JV-285**

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Introduction

The purpose of this agreement was to develop models that predict change in crown length attributes for species that are represented in the North Idaho variant of the Forest Vegetation Simulator (NIFVS). The current NIFVS employs regression models that were fit to inventory data and predict static estimates of crown ratio. Changes in crown ratio are estimated by differencing crown ratio predictions from the beginning and end of a projection cycle. This crown change estimate is adequate for tree growth estimation, but links to other components of forest resource evaluation are tenuous at best. Improved crown dynamics models will facilitate the representation of fire behavior and the evaluation of fire effects. Further, models that predict development of non-timber vegetation, wildlife habitat, and impacts of erosion will be better served by a crown model that is more closely coupled to understory light regimes. An improved crown dynamics model will also facilitate product valuation and assessment of carbon sequestration rates. Elements of crown dynamics that are of particular interest include vertical and horizontal extension, number and maximum size of branches in specific bole segments, rates of branch mortality and sloughing of dead branches, and the size of the foliated shell on the exterior of the crown.

Study Area

University of Idaho Experimental Forest

The University of Experimental Forest (UI) is a diverse forest typical of the drier mountains of northern Idaho. Precipitation averages 27 inches per year, with the majority falling as rain and snow during the fall, winter, and spring. Grand fir and Douglas-fir are the most common tree species. Western redcedar, ponderosa pine, western larch, western white pine, lodgepole pine, Engelmann spruce, western hemlock, and subalpine fir are also found in varying quantities.

Priest River Experimental Forest

The Priest River Experimental Forest (PREF) encompasses 2,590 ha, with elevations ranging from 680 to 1,800 m. There are two major east-to-west drainages that bisect the forest, which result in predominantly north- to northwest- and south- to southwest facing slopes. Priest River is influenced by the Pacific Ocean, so the climate can be categorized as modified maritime. Precipitation averages 810 mm, with most of the moisture falling as snow in the winter. Summers are usually dry and the mean annual temperature is 6.6° C. Five major forest types are supported within PREF: subalpine fir, grand fir, western hemlock, Douglas-fir, and western redcedar. Within these types, western larch,

lodgepole pine, ponderosa pine, and western white pine are frequent associates. Forest ages range in age from 20 to more than 200 years, but the age of most trees ranges from 80 to 160 years. Soils are Typic Vitrandepts, with a thick mantle of volcanic ash overlaying belt series parent material.

Mica Creek Experimental Watershed

The Mica Creek Experimental Watershed (MICA) is a paired and nested catchment study basin, privately operated by Potlatch Corporation. It is located in northern Idaho approximately 42 miles southeast of Coeur d'Alene Idaho. The experimental watershed encompasses the Mica Creek and the West Fork of Mica Creek (2700 hectares) catchments, which are tributaries to the St. Joe River. The experimental watershed varies in elevation from 1000 to 1585 m at the headwaters, and receives approximately 1400 mm of annual precipitation. Both continental and maritime weather patterns influence the watershed. The majority of precipitation falls from November to May, with greater than 50% of all precipitation falling as snow. Rain-on-snow events are common in the lower elevations. The geology of the watershed includes quartzite and gneiss in the upper end and pockets of schist further downstream. Vegetation comprises 60-70 yr. old mixed conifers.

Description of existing data

The existing data available were collected beginning in 1988 at PREF with the objective of using mensurational and genetic techniques to gain an understanding of the factors determining the growth and development of mature trees. The study site was located at PREF. The site was chosen because it has uninterrupted weather records since 1911 as well as a diversity of forest conditions and habitats. Three species were included in the study: western white pine (*Pinus monticola*), ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*). Stands were constrained to be in the same seed zone (about 198 m in elevation for Douglas-fir, 366 m for ponderosa pine, and no restrictions for white pine), and in close proximity to the weather station.

Trees included in the sample had an adequate cone crop, no apparent damage, and a radial growth pattern that gave no indication of past damage. Trees of a given species were separated by at least three crowns to prevent consanguineous matings, and tree age was limited to 80 years or less. In total, 185 trees were selected for sampling.

A series of standard inventory plots were established in each stand in August, 1988, and density estimates were obtained from 4.6 m² ha⁻¹ BAF prism points. For each point, a subsample of height, crown ratio and radial growth was taken, and the diameter and species of every tally tree was recorded as well as slope, aspect, elevation and habitat type).

Height growth was determined for each tree by measuring the distance between the bases of adjacent annual whorls. Approximately every tenth whorl was sectioned and counted for annual whorls to verify the whorl count. In the event that the ring count did not match the whorl count, the bole was sectioned until the disparity was removed. The 10-year sections were measured for diameter inside bark (dib) and removed to the lab for radial growth measurement. Crown base was determined using the definition of Maguire

and Hann (1987): lowest contiguous live whorl (lclw) was the lowest live whorl above which all whorls had at least one live branch. For every whorl beginning at the crown base (lclw) and working to the base of the tree, a 0.15 m thick bole section containing the branch stubs was sawn out, labeled, and removed to the lab. Stump height and age was measured so that total height and age were known for each tree, and the number of whorls below the stump cut were also recorded if they were visible.

Wedges containing the branches were split out of every whorl section and labeled. Using a bandsaw, branches were then sawn lengthwise to the pitch in a direction that was perpendicular to the axis of the bole. Year of mortality was determined for every branch below crown base using the methods of Maguire and Hann (1987), and then the lclw definition was determined for every year of the tree's life.

Prototype Models

Prototype models were developed for branch diameter within specific bole segments. The models were evaluated by Andrew Robinson and William Wykoff. Since the models were based on the assumption of linear growth throughout the life of the branch in absence of a better growth function, they were used only to direct future sampling procedures.

Data requirements and field sampling procedures

A major limitation within the existing data set is the lack of information regarding the live crown. In order to develop models with the ability to predict the diameter of branches within specific crown segments, additional data was necessary. The branch diameter data within the existing data set included only diameters of dead branches; since the branches died at varying times the diameters are not directly comparable. Additionally, the existing data set did not include observations for overall and foliated branch length.

To augment the existing data and include live branch data, the following field sampling plan was developed and 120 trees were destructively sampled during the summers of 2004 and 2005.

Plots will be chosen to represent a broad range of variability in northern Idaho. The goal is to have high and low density categories and young and old trees in each density category. Within a stand, plots will be chosen by selecting a compass bearing, then moving 30 m into the stand from the edge. If the plot contains at least two of the three species of interest, we will proceed with sampling. If the plot does not contain at least two of the three species, we will move 30 m along the same bearing as the first and again check for the species mix. If we check three plots on the same bearing without finding the necessary species mix, we will move to a new starting location and repeat the process.

Trees will be selected for sampling using a variable radius plot. A 4 m² ha⁻¹ BAF prism will be used to tally trees within the plot beginning with the first tree to the right of north and continuing clockwise. Diameter (cm) at breast height will be measured along

with species for each tree in the tally. The diameters will be ordered and the median diameter will be noted for each plot. For each of the species of interest within the plot, the first tree (from north) larger than the median will be sampled, and the first tree smaller than the median will be sampled. In plots with an uneven number of trees in the tally, we will not include the median as a sampled tree for consistency.

The chosen trees from each site will be felled for destructive sampling following the methods of Monserud and Marshall (1999). Whole tree measurements include total height of tree, height to crown base, and crown length. The crown base is defined as the lowest whorl with at least two live branches such that there are no dead whorls above that whorl (Maguire and Hann 1987). The live crown will be divided into quarters and marked at each quarter. Above the crown base, branch diameters will be measured with calipers in each crown quarter, and it will be noted whether the branch is dead, live or broken and its height on the bole. Within each crown quarter, two branches will be randomly sampled for detailed measurements.

Detailed branch measurements will begin with green weights taken in the field (Monserud and Marshall 1999). Needle samples will be taken from each of the sampled branches, both current and older needles. The needles will be frozen until they can be weighed in the lab and scanned for leaf area. Following being weighed green and scanned, the needles will be dried at 70° C to obtain dry weights. The branches will be measured for foliated length, length of each annual node, and length of each secondary branch. Branch diameters will be measured at the beginning of the foliage, and at three equal distances from the foliated edge to the tip of the branch. All of the needles will be stripped from the branches to separate foliage from wood, then the branches will be dried at 70° C and reweighed.

Two-inch thick disks will be cut from the bole at the stump, breast height, ten percent of total height, thirty-three percent of total height, crown base, and each of the three crown quarter marks above the base of live crown. The disks will be weighed green in the field, and then dried for several weeks on pallets before being dried in a 70° C oven and re-weighed. Diameters will be recorded for each disk at the largest diameter both inside and outside bark, and at 90° from the largest diameter both inside and outside bark. Each disk will be aged using a dendrometer.

References

- Maguire, Douglas A., and David W. Hann. 1987. A stem dissection technique for dating branch mortality and reconstructing past crown recession. *Forest Science*. 33(4): 858-871.
- Monserud, R. A. and J. D. Marshall. 1999. Allometric crown relations in three northern Idaho conifer species. *Canadian Journal of Forest Research*. 29:521-535.